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Motor fluency and preference judgments: typing speed as a predictor of letter dyads' likeability

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3 1 **Motor fluency and preference judgments:**
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5 2 **typing speed as a predictor of letter dyads' likeability**
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10 4 **Abstract**
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12 5 The literature on embodied cognition has shown that the perception of action-related stimuli
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14 6 can trigger a covert motor simulation of the action usually associated with these stimuli. Such
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16 7 simulation is thus closely linked to previous experiences with the objects and hence to
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18 8 memory processes. Preliminary evidence shows that sensorimotor fluency originating from
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20 9 the motor system can influence higher cognitive processes, such as preference judgments,
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22 10 when observing action-related stimuli, such as letter dyads (e.g., “FA”, “TR”): fluent (easier
23
24 11 to type) dyads on the QWERTY keyboard are preferred over non-fluent dyads. These effects
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26 12 were attributed to the automatic activation of fluent motor programs during the observation of
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28 13 dyads. With the aim of gaining a better understanding of the role of fluency in preference
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30 14 judgments, here we further investigate this effect by comparing slow and fast typists, who
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32 15 should have different motor programs associated with the dyads and should therefore show
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34 16 different preferences. Our results show that fluency affects likeability of letter dyads, but in
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36 17 different ways for slow and fast typists: slow participants showed a preference for fluent
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38 18 dyads, while fast participants did not. We concluded that fast typists, who are characterized
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40 19 by greater typing skills, considered both types of dyads as subjectively fluent, leading to no
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42 20 specific preferences, while slow typists, who are characterized by lower typing skills,
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44 21 preferred easy dyads.
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53 23 **Keywords:** motor fluency, preference judgments, simulation, keyboard.
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Introduction

7 27 Which are the cognitive processes that drive the judgment of likability of tasks,
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9 28 objects, and other stimuli encountered in everyday life? Are these processes purely aesthetic
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11 29 (abstract) judgments that are independent of perceptual and motor systems, or are they
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13 30 closely connected to motor resources and motor schemas derived from the previous
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15 31 experiences with these stimuli?
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18 32 The embodied cognition approach (for a summary picture of the state of the art e.g.,
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20 33 Robinson & Thomas, 2021; for a critical discussion e.g., Iani, 2022), as well as several
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22 34 empirical findings (e.g., Ping et al, 2009), seem to support the latter view. Preference
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24 35 judgments depend heavily on previous experiences involving interactions with a given
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26 36 everyday object, a factor that usually reinforces positive affect toward that object (for a
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28 37 review, see Reber et al., 2004). This phenomenon is attributed to the “sense of fluency” that
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30 38 results from previous interactions with the object. Fluency has been defined as “a feeling of
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32 39 ease associated with a cognitive operation” (Oppenheimer, 2008; p. 237). Fluency is
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34 40 activated when an object is perceived and can lead to higher preference of objects compared
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36 41 to the ones associated with lower fluency (e.g., Vrana & Van den Bergh, 1995).
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42 42 Here, we focus on a specific type of fluency, namely motor fluency, which is related
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44 43 to the activation, speed, and effort of a motor activity, i.e. the perceived ease with which an
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46 44 action can be performed (Milhau et al., 2015). This focus stems from the embodied cognition
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48 45 literature, assuming that motor information can be covertly activated during the perception of
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50 46 an object (e.g., Barsalou, 2008; Ellis & Tucker, 2000), and more generally emphasizes the
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52 47 functional links between cognition and action (Glenberg, 2010). Indeed, approaches to
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54 48 embodied cognition highlight the fragility of some boundaries, particularly that between
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56 49 motor functions and perception, and more generally the flexibility of cognitive functions, a
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58 50 critical point also recently emphasised by the “complex dynamic system” framework (e.g.,
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3 51 Larsen-Freeman, 2015), along as the need to study cognition as inherently context-dependent
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5 52 and as fundamentally processual.
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8 53 Covert simulations triggered by objects depend on previous experience (Iani, 2019)
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10 54 and affect cognitive function in several ways. For example, Chrysikou et al. (2017) presented
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12 55 graspable objects with handles depicted either on the left or right hand side, and asked
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14 56 participants to indicate with which kind of grasp (e.g., pinch or clench) they would interact
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16 57 with the object. Their results showed that objects oriented to the right (compared to the left)
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18 58 were judged faster by right-handed participants, indicating that motor experience influences
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20 59 object processing. In this line, the body specificity hypothesis postulates (and has shown
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22 60 empirically), how motor experience (e.g., the handedness of individuals) impacts likeability
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24 61 judgments, e.g., left handed individuals associated “good” with left, while right handed
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26 62 individuals associated “good” with right (e.g., Casasanto, 2009). Likeability judgements are
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28 63 also impacted by motor fluency. For example, Hayes et al. (2008) found higher likeability
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30 64 ratings for objects that were moved fluently (compared to non-fluently). These results seem
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32 65 to suggest that, because the mere perception of an object triggers motor programs that tell us
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34 66 how difficult it would be to interact with it, “individuals who are asked to make judgments
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36 67 about how much they like a particular object or stimulus might prefer objects that are easy to
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38 68 interact with” (Ping et al., 2009, p.145).
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44 69 The QWERTY keyboard has been shown to be suitable in various experimental
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46 70 paradigms to test the role of motor simulation and motor fluency in preference judgements of
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48 71 letter dyads (e.g., Iani et al., 2024; Rieger, 2011). For instance, the so-called “QWERTY-
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50 72 effect” (Jasmin & Casasanto, 2012) refers to the phenomenon according to which words with
51
52 73 more right-side letters (on the keyboard) are evaluated more positively compared to words
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54 74 with more left-side letters, crucially even when they are not typed by participants. As this
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56 75 effect is in contrast to the body specificity hypothesis, replicated both in left and right handed
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3 76 individuals (Jasmin & Casasanto, 2012), different mechanisms are likely to be responsible for
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5 77 this effect. The authors hypothesize this effect to be based on the implicit activation of
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7 78 familiar motor patterns in perceiving and processing letters and words (see also Casasanto et
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10 79 al., 2014). Due to the asymmetrical arrangement of the QWERTY keyboard, fluency of
11
12 80 typing letters is increased on the right side because there are fewer keys, and thus, less
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14 81 competition for fingers in typing (e.g., Buchanan et al., 2022), supporting the role of motor
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16 82 experience in affective evaluations. In this line, literature has also investigated typing fluency
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18 83 specifically arising from the specific use of the fingers the keys are typed with. According to
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20 84 the standard keyboard input (touch-typing practice), some dyads are typed with two different
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22 85 fingers (e.g., FK) and other dyads with one single finger (e.g., FV). Since successive
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24 86 keystrokes are expected to overlap during typing (Rumelhart & Norman, 1982), typing two
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26 87 letters with the same finger results in higher motor interference (in regards to the preparation
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28 88 for the second keystroke) than typing two letters with different fingers. Therefore, dyads
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30 89 typed with two different fingers are easier, thus more fluent (fluent dyads), to type than dyads
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32 90 typed with the same finger (non-fluent dyads).

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37 91 Yang et al. (2009) investigated whether these kinds of motor fluency affect
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39 92 recognition memory by presenting, in a first phase, both fluent and non-fluent letter dyads,
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41 93 one by one, to their participants. In a surprise memory task, participants were then shown old
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43 94 (i.e. studied) and new (i.e. non-studied) letter dyads and had to judge whether they had seen
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45 95 them or not. Results showed that expert typists, compared to novices, made more false
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47 96 recognition errors on fluent letter pairs (i.e. typed with different fingers of different hands)
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49 97 compared to non-fluent pairs (i.e., typed with the same finger of the same hand). The authors
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51 98 suggest that memory is influenced by the covert simulation of actions associated with the
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53 99 items being judged—even when there is no intention to act. The underlying mechanism is
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3 100 expected to be a subjective sense of familiarity, conveyed by motor fluency that influences
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5 101 episodic memory judgments.
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8 102 In this line, also likeability judgements have been investigated applying the same
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10 103 paradigm. A seminal study by Van den Bergh et al. (1990) has shown that expert typists,
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12 104 when presented with fluent and non-fluent letter combinations in a forced-choice paradigm,
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14 105 preferred more frequently fluent dyads. Beilock and Holt (2007) replicated these findings on
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16 106 skilled typists, i.e., participants who had taken a formal typing course, typed at least 3 hours
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18 107 per week, kept their fingers on the “home keys” while typing and only occasionally looked at
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20 108 the keyboard while typing. Both skilled and novice typists were asked to indicate which of
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22 109 two types of letter dyads they preferred. The results revealed that, although participants were
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24 110 not explicitly aware of the difference between dyads, expert typists preferred dyads typed
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26 111 with different fingers, whereas novice typists showed no preference. In a second experiment,
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28 112 the authors illustrated the role of motor simulation in the motor fluency effect: when
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30 113 participants carried out a motor task involving the same fingers that would be used to type the
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32 114 presented letter dyads, the preference for fluent dyads was attenuated (Beilock & Holt, 2007).
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38 115 Differently from previous work on this topic, to further investigate the role of motor
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40 116 fluency elicited by a covert motor simulation on cognitive judgments (preference/likeability
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42 117 judgments), in the present study we compared, for the first time, slow and fast typists rather
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44 118 than expert and novice typists. The literature in this regard has not been updated in over a
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46 119 decade (i.e., Beilock & Holt, 2007; Van den Bergh et al., 1990). This represents a crucial gap
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48 120 given that typing and keyboard exposure have considerably changed over the last decades,
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50 121 leading to a full integration of the keyboard in most every-day life activities and consequently
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52 122 to a very common high typing experience. Pinet et al. (2022) found that the standard
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54 123 distinction between novice and expert typists (as used in older studies on this topic e.g.,
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56 124 Beilock & Holt, 2007 or Yang et al., 2009) is inaccurate nowadays when attempting to
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3 125 account for typing performance in young typists (classically reported variables on typing
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5 126 performance are also present in least proficient typists). Therefore, older studies are not
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7 127 generalizable to the current generation of young typists and consequently, some effects found
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9 128 in the literature and based on this distinction might no longer reflect the reality. Also, the
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11 129 cognitive architecture underpinning typing might have changed in (previously called) novice
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13 130 typists. For instance, Beilock and Holt (2007), when showing that preference rates of letter
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15 131 dyads are based on sensorimotor simulation of typing, found evidence only in expert typists
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17 132 for a motor fluency effect when judging letter dyads. These results might have changed with
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19 133 the development of characteristics of typing expertise, and might no longer represent the
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21 134 current cognitive and sensorimotor functioning of “novice” typists.

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26 135 In this study, we therefore used a modified version of the letter dyad preference task
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28 136 used by Beilock and Holt (2007) and Van den Bergh et al. (1990). Specifically, in contrast to
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30 137 the latter authors, we did not apply a forced-choice paradigm but presented letter dyads one
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32 138 by one in order to test *absolute* preference judgments (not relative ones as in the former
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34 139 studies, see e.g., Jou et al., 2016 for underlying cognitive processes). Moreover, we assessed
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36 140 the degree of expertise not by evaluating the traditional expert typists criteria, such as having
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38 141 received formal typing instructions or keeping fingers on the home keys when typing (see
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40 142 e.g., Van den Bergh et al., 1990; Yang et al., 2009). Instead, we measured their average
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42 143 typing speed in a typing task (as in Buchanan et al., 2022; Dhaka et al., 2018 or Pinet et al.,
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44 144 2022). Since motor fluency effects are based on the previous experience with the keyboard
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46 145 and the specific motor repertoire associated, we expected the fluency effect (fluent dyads
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48 146 perceived as more likeable than non-fluent ones) to differ **based on the typing speed** which is
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50 147 associated with distinct motor abilities, however, as this is the first study to test fluency
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52 148 effects on the current generation of typists, we maintained an exploratory hypothesis in
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54 149 regards to the direction of the effect. **In fact, on one hand, it is possible to extend findings by**
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3 150 older studies on expert/non-expert participants in our study by manipulating fast/slow
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5 151 participants. Thus, we could expect that fast typists prefer fluent over non fluent dyads whilst
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8 152 slow typists could possibly also exhibit an analogous preference pattern, but in a less marked
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10 153 way (due to their less specialized typing proficiency, i.e., speed). On the other hand, it is
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12 154 possible that the new generation of typists, due to their overall increased exposure to the
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14 155 keyboard and typing, do not subjectively perceive the same classical difference in typing
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16 156 fluency as previous expert/no-expert participants, leading to either no difference in preference
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18 157 judgments or to a enhanced difference in perceived fluency vs. non fluency in less proficient
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21 158 typists.

159 Experiment

160 Participants

161 We tested 30 Italian young adults (18 females, 12 males, mean age = 24.93, $SD = 3.29$),
162 recruited from [REDACTED]. The necessary sample size was calculated via
163 G*Power 3.1; based on a large effect size ($d = .71$) evidenced by Beilock and Holt (2007) in
164 regards to preference rates of fluent dyads, the power analysis for mixed ANOVAS suggested
165 a minimum number of 22 participants. All participants were Italian native speakers and users
166 of the Italian keyboard. Participants were recruited for a study “on cognitive processes” and
167 were told the true study objective only at debriefing. 25 participants were right handed (4
168 ambidextrous, 1 left handed) and all had normal to corrected vision. Out of all participants,
169 only one typist fulfilled all of the 4 classical criteria to be an “expert” typist (see above) and
170 none of them fulfilled 0 criteria, in order to be classified as a “novice” typist according to the
171 previous studies (e.g., Beilock & Holt, 2007; Van den Bergh et al., 1990). The sample was
172 divided into two groups based on their mean typing speed: fast typists (1) $N = 16$ (typing
173 speed < mean), and slow typists (0), $N = 14$ (typing speed > mean). Typing speed (corrected

174 score, see *Data analysis*) differed significantly between the two groups ($t(28) = 8.45$, $p <$
 175 $.001$, *Cohen's d* = .50).

176 **Materials**

177 **Thirty-two** dyads of the Italian Alphabet were chosen. All dyads, if typed with the
 178 standard touch-typing technique, would be typed with index and middle fingers on an Italian
 179 QWERTY keyboard. Half of the dyads (16 items) are fluent dyads, thus typed with two
 180 different fingers of two different hands whereas the other half (16 items) are typed with the
 181 same finger of the same hand¹. Applying analogous criteria to Yang et al. (2009), we
 182 excluded dyads that have a meaning in the Italian language, that are abbreviations, moreover,
 183 their frequencies based on the phonological lexicon created by Goslin et al. (2014) were
 184 taken into account. Mean frequencies between fluent and non-fluent dyads did not differ
 185 significantly (Fluent Dyads: $M = 22356.19$ ($SD = 49576.44$); Non-fluent Dyads: $M =$
 186 10289.94 ($SD = 26429.51$); $t(30) = .859$, $p = .39$). We divided the 32 dyads into two sets of
 187 stimuli (16 dyads each) with 8 fluent and 8 non fluent dyads for each set (see Table 1).

188 **Table 1.**

189 *Chosen Dyads and their Attributes*

Set	Dyad	Type	Finger	Hand
1	RT	S	II	LL
	FR	S	II	LL
	FT	S	II	LL
	GF	S	II	LL
	NM	S	II	RR

¹ In order to ascertain that the distinction between fluent and non-fluent dyads is still relevant in today's generation of typists, we carried out a control study on a comparable sample of students ($N = 24$, not significantly different in age ($t(52) = .29$, $p = .77$) or education level ($\chi^2(4) = 6.00$, $p = .20$). The study confirmed that they type both fluent and non fluent dyads according to the classification criteria (i.e., with different or same hands, respectively). See Appendix A for a detailed description of the task and results.

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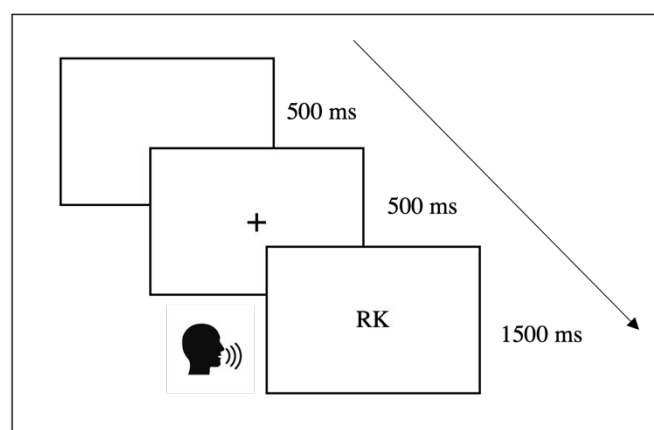
	UH	S	II	RR
	HN	S	II	RR
	YU	S	II	RR
	GK	D	IM	LR
	FK	D	IM	LR
	JE	D	IM	RL
	MC	D	IM	RL
	CY	D	MI	LR
	DM	D	MI	LR
	IV	D	MI	RL
	KR	D	MI	RL
<hr/>				
2	RG	S	II	LL
	RV	S	II	LL
	VR	S	II	LL
	TF	S	II	LL
	UM	S	II	RR
	HY	S	II	RR
	YM	S	II	RR
	JN	S	II	RR
	RI	D	IM	LR
	RK	D	IM	LR
	YE	D	IM	RL
	YC	D	IM	RL
	CN	D	MI	LR
	EJ	D	MI	LR
	IR	D	MI	RL
	IG	D	MI	RL

190 *Notes.* Type: D = different finger dyads (fluent), S = same finger dyads (non-fluent); Finger: fingers
 191 involved in typing the dyads: I = index finger, M = middle finger; Hands: hands involved in typing the
 192 dyads: R = right hand, L = left hand.

193 **Procedure**

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3 194 Participants were seated in front of a portable computer, their fingers were placed on
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6 195 the home keys of the Italian, while their sight of the keyboard was hindered by a box under
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8 196 which their hands were placed (for a similar procedure see Beilock & Holt, 2007 and Yang et
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10 197 al., 2009). They received the instruction to not press any keys or move their hands until the
11
12 198 first part of the experiment was completed (the lateral opening of the box allowed the
13
14 199 experimenter to ensure adherence to these instructions). Subsequently, participants completed
15
16 200 the preference task. Sixteen dyads (participants were randomly assigned to block 1 or 2), 8
17
18 201 fluent and 8 non-fluent, appeared on the screen for 1500 ms in a random order and one at a
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20 202 time. After that, a white screen (500ms) and a fixation cross (500ms) appeared. Participants
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22 203 received the instruction to orally judge (in order to avoid possible motor interferences with
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24 204 the expected sensorimotor typing simulation, see Beilock & Holt, 2007; Yang et al., 2009),
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26 205 each item. More specifically, and also in line with the aforementioned literature, they were
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28 206 asked to indicate the degree of likeability regarding each letter pair by saying out loud “yes”
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30 207 if they liked it or “no” if they did not like it. We decided to adopt this methodology to obtain
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32 208 comparable results with similar studies using the same procedure. They were instructed to
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34 209 give a spontaneous immediate response based on their first impression; verbal answers were
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36 210 recorded during the whole trial.
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43 211 **Figure 1.** Procedure of the preference task.



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214 In the second part of the experiment, participants completed the typing task in which
215 they were asked to type an Italian sentence (128 characters including spaces, see Appendix
216 B), used as a measure of typing speed/fluency as in Logan and Zbrodoff (1998).

217 The sentence was displayed in the center of the screen (E-prime settings: 50 %
218 horizontally, 50 % vertically) and remained on the screen for the entire task. Typed letters
219 were echoed on the screen, while the keyboard was visible to the participants in order to
220 ensure an accurate measure of their typical typing behavior. Participants did not receive
221 specific instructions on how to type (as in Pinet et al., 2022). Response time was recorded
222 from trial onset to the last keystroke whilst the keypress of the last character (see Appendix
223 B) determined task completion. Subsequently, they were asked about perceived differences
224 between two columns of fluent and non-fluent dyads, in order to ascertain that they were not
225 aware of differences in motor fluency (see Appendix C). No participant guessed the
226 difference across dyads to be typing fluency. Finally, the Edinburgh Handedness Inventory
227 (EHI, Olfield, 1971; Salmaso & Longoni, 1985) was administered and participants were
228 debriefed. The whole procedure was carried out on E Prime 3.0 and lasted around 15 minutes.

229

Results

230 Preference rates were created attributing a score of 1 to each “yes” answer indicating
231 the liking of a letter dyad and a score of 0 to each “no” answer. Average preference rates
232 ranging from 0 to 1 were calculated, both for fluent and non-fluent dyads. Typing speed was
233 calculated using the time (in ms) from the first to the last keystroke executed in the typing
234 task. We computed a corrected typing speed score by penalizing mistakes, adding 2 times the
235 mean character typing speed (mean typing speed of texts without mistakes / number of
236 characters) for each mistake. Typing speed followed a normal distribution (Shapiro-Wilk

237 normality test: $W = .97, p = .64$) and groups were divided based on the corrected typing speed
 238 score. All data analyses were computed on RStudio (Version 2023.03.0+386).

239 Descriptive statistics of preference rates as well as typing speed are reported in Table 2.

240 **Table 2.** *Descriptive statistics based on typing speed groups*

Group	Mean preference rates (SD)		WPM (SD)
	Fluent (D)	Non fluent (S)	
Slow typists	.63 (.15)	.45 (.14)	28.75 (3.17)
Fast typists	.53 (.16)	.57 (.16)	44.86 (8.95)

241 *Note.* WPM (Words Per Minute) = typing speed index calculated based on mean typing speed (time (s)
 242 needed to type text / number of words (23) X 60).

244 A 2 (fast vs. slow typists) x 2 (fluent vs. non-fluent dyads) ANOVA did not reveal
 245 significant main effects for Typing Speed Group ($F(1,28) = .07, p = .80, \eta_p^2 = .00$) or Dyad
 246 Type ($F(1,28) = 2.49, p = .13, \eta_p^2 = .08$), but a significant interaction between Dyad Type
 247 and Typing Speed Group ($F(1, 28) = 6.49, p < .01, \eta_p^2 = .188$) was found². A subsequent t-
 248 test for dependent samples illustrated a significant difference in preference rates for easy vs
 249 difficult dyads only in slow typists ($t(13) = 2.625, p < .05, Cohens'd = .702$), whereas no
 250 significant difference was found in fast typists ($t(15) = -.764, p = .46, Cohens'd = -.191$).

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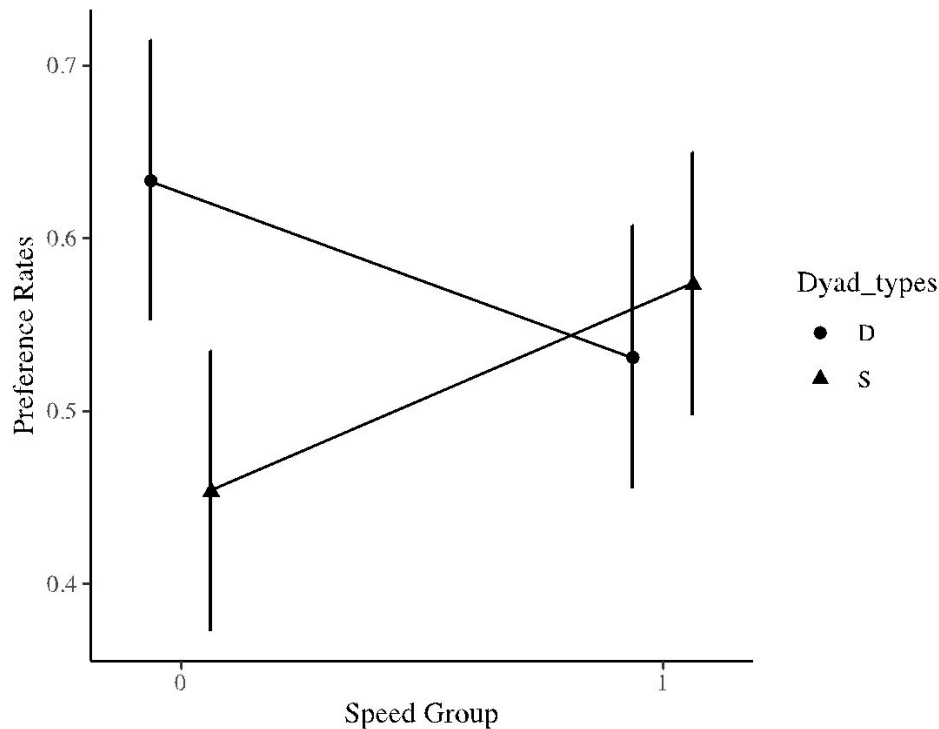
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² Please note that same result was found when, in line with the statistical methodology of Beilock and Holt (2007), a single preference index (> 1 = preference for non-fluent dyads and < 1 = preference for fluent dyads) was computed and a one-way ANOVA with speed group as an independent variable, was run ($F(1,28) = 5.54, p < .05$). Moreover, an analogous result was also found when dividing the sample into fast vs. slow typists by using a median split ($F(1,28) = 4.86, p < .05, \eta_p^2 = .10$).

261

Figure 2. *Predicted reference rates for letter dyads*

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263 *Notes. Dyad types: D = fluent dyads, S = non-fluent dyads; Speed Group: 0 = slow typists, 1*
 264 *= fast typists.*

265

Discussion

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In this study we tested if motor fluency effects can impact likeability ratings of letter dyads, considering typing speed as a discriminative variable. The present findings show differences in likeability between fluent and non-fluent dyads also when assessed in a single-choice paradigm (compared to two-alternative forced choice tasks as applied in previous studies; Beilock & Holt, 2007; Van den Bergh et al., 2010) but only in the slow typists group: slow typists preferred fluent dyads significantly over non-fluent dyads whereas no significant likeability difference was found for fast typists. This effect is likely due to the sensorimotor simulation of the typing action which is automatically activated when judging the dyads and leads to slow typists (those whom typing non fluent dyads should be more complicated) feeling more fluency and therefore preferring fluent dyads.

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3 276 Interestingly, these results are in contrast with previous results in the literature (e.g.,
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5 277 Beilock & Holt, 2007; Van den Bergh et al., 1990, who found *expert* typists to prefer fluent
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7 278 dyads over non-fluent dyads). We argue, however, that our results are related to the
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10 279 widespread development of typing-related cognition in the last decade (e.g., Pinet et al.,
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12 280 2022). First of all, our results indicate that with a greater frequency of (non-expert) use of a
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14 281 keyboard in the general population also slow (thus, less skilled) typists may have a mental
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16 282 representation of the keyboard, and might be able to activate a sensorimotor simulation of
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19 283 typing when perceiving letter dyads (whereas Beilock & Holt, 2007 or Yang et al., 2009
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21 284 argued that novice typists were not be able to do so). This also confirms that even in less
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23 285 skilled typists motor fluency can lead to higher likeability/ preference of letter dyads (e.g.,
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26 286 Beilock & Holt, 2007; Forster et al., 2016; Hayes et al., 2008).

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28 287 Moreover, we argue that the null-finding regarding the lack of preference in fast
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30 288 typists is not related to missing sensorimotor simulation in this group. *Rather, we hypothesize*
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32 289 *that fast typists, characterized by overall greater motor experience and stronger typing skills,*
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34 290 *perceive a subjective ease in typing both objectively easy and difficult dyads, due to their*
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36 291 *overall “fluent” typing behavior. In slow typists, instead, the objective easiness / difficulty in*
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38 292 *typing might correspond also to their subjectively perceived fluency, leading to preferring*
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40 293 *dyads that are objectively easier to be typed.*

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44 294 This claim is supported by the literature on other kinds of fluency, e.g., perceptual
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46 295 fluency, which provides evidence for the importance of the subjective feeling of fluency,
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48 296 rather than the mere objective fluency. For instance, Forster et al. (2013) showed stronger
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50 297 effects of processing fluency on liking if subjective fluency was taken into consideration. In
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52 298 fact, objective motor fluency of letter dyads, if interpreted as bimanual (fluent) vs. unimanual
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54 299 (non-fluent) inter-keystroke-intervals (IKI - this is the time occurring between two
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56 300 consecutive keystrokes) shows controversial results regarding the typing speed of these two
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3 301 types of dyads in slow and fast typists. Feit et al. (2016), who compared touch-typists and
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5 302 non-touch typists, found that only the latter (with less formal expertise) are faster at typing
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7 303 bigrams with alternating hands and fingers compared to the same finger. However, they
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9 304 distinguished typists based on classical criteria, so this finding cannot be directly interpreted
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11 305 in the light of the present results that are based on typing *speed*. On the other hand, Pinet et
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13 306 al. (2022) divided their sample into proficient and least proficient typists based on typing
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15 307 speed and typing accuracy; while they found bimanual IKI to be faster in both groups, the
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17 308 effect was significantly stronger for proficient typists, indicating a stronger effect of objective
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19 309 motor fluency in proficient typists. However, as argued above, this is not necessarily in
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21 310 contrast to our results; we expect preference judgements to rely on *subjectively* perceived
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23 311 typing fluency, thus, whilst fast typists might not subjectively perceive any type of dyad
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25 312 difficult to type, slow typists might have preferred fluent dyads based on their perceived
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27 313 easiness when typing them.

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33 314 Thus, further studies would be needed to fully explain the present results investigating
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35 315 both the subjective (perceived ease when typing different dyads types) as well as the
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37 316 objective motor fluency (i.e., unimanual vs. bimanual IKIs, considering same vs. different
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39 317 fingers) in slow and fast typists, and how these two kinds of motor fluency (distinctly) impact
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41 318 likeability ratings of objects. Moreover, it is important to note that the digitalization of the
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43 319 last centuries has not only led to a more frequent exposure of the classical computer keyboard
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45 320 but also different technologies such as smartphones or tablets with touchscreen (keyboards)
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47 321 which could possibly also impact motor fluency (see e.g., Maisto & Actis-Grosso, 2023 for
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49 322 an example of motor fluency for swiping on a touchscreen in which they replicated the body
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51 323 specificity hypothesis or Craighero et al. (2023) for evidence suggesting different
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53 324 sensorimotor competence in touchscreen typing with two thumbs vs. one finger). Thus, future
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55 325 research could investigate how the interaction with these devices influence results differently.
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3 326 Finally, it is worth noting that our study is not without limitations. From a methodological
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5 327 point of view, our study should be extended on a bigger sample size in order to be able to
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7 328 draw some more robust conclusions. Moreover, applying a Likert- scale to investigate
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9 329 likeability ratings (see e.g. Buchanan et al., 2022) could provide further insight into the nature
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11 330 of affective judgments impacted by motor experience. However, our current findings do not
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13 331 currently allow to determine the causal role of motor simulation for our results, thus, further
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15 332 research would be needed, interfering with the postulated typing simulation (e.g., with a
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17 333 secondary motor task or with Transcranial Magnetic Stimulation, see Beilock & Holt, 2007
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19 334 or Candidi et al., 2014), to determine the role of sensorimotor simulation. Finally, given the
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21 335 well-established literature on the relevance of handedness in different types of motor fluency
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23 336 (e.g., Casanto & Chrysikou, 2011; Chen & Lin, 2021) and the recent interaction found
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25 337 between the QWERTY effect and finger-switching in typing (Buchanan et al., 2022) it would
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27 338 be interesting to investigate if this also extends to typing motor fluency.
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33 339 In conclusion, the present study provides an interesting insight into the impact of motor
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35 340 fluency on positive object evaluations elicited by a covert sensorimotor typing simulation,
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37 341 and expands recent research on typing-related cognition highlighting notable changes in its
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39 342 (embodied) cognitive functioning compared to past research in this context.
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45 344 **Declarations**

46
47 345 **Ethics approval and consent to participate.** This study was performed in line with the principles of the
48
49 346 Declaration of Helsinki. Approval was granted by the Ethics Committee [REDACTED]

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51 347 **Availability of data and material.** All data is available at:

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53 348 https://osf.io/9j3d4/?view_only=0e8fd9f21cf445329e21af4bdf172e26

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55 349 **Competing interests.** The authors declare that they have no competing interests.

56
57 350 **Funding.** This research was partially funded by [REDACTED]

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59 351 [REDACTED]
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Appendix A

464 In order to ascertain that the classification between fluent and non-fluent dyads, based on the
465 way they are typed (different fingers/hands and same fingers/same hands), is still relevant in
466 today's generation of young adults, we conducted a control study.

467 *Participants.* 24 Italian students (mean age = 25.21; $SD = 3.67$; 21 females) from the same
468 university course were recruited and participated in the online study carried out on E-prime
469 go. All participants were users of the QWERTY keyboard, had normal to corrected-to-normal
470 vision and no neurological or psychiatric conditions. 21 participants were right-handed and 3
471 participants were left-handed. Regarding comparability with the sample of the main
472 experiment, a t-test for independent samples showed that the participants did not differ
473 significantly in age ($t(52) = .29, p = .77$) compared to the participants of the main experiment
474 (which is also by supported by Bayes Factor analysis, $BF_{01} = 3.51$, providing substantial
475 evidence in favour of the null hypothesis). Moreover, a χ^2 test showed that education level
476 was not differently distributed between the two samples ($\chi^2(4) = 6.00, p = .20$), which was
477 again confirmed by BF analysis ($BF_{01} = 5.91$), providing positive support for the null
478 hypothesis (i.e., no difference between the two samples) compared to the alternative
479 hypothesis.

480 *Materials.* The same 32 dyads (16 fluent and 16 non-fluent) from the main experiment were
481 used.

482 *Procedure.* After signing the informed consent and providing socio-demographic
483 information, participants were presented, in randomized order, with all 32 dyads. More
484 specifically, in each trial, one dyad at a time appeared in the center of the screen and
485 participants were first asked to type the dyad. Subsequently, whilst the dyad remained on the
486 screen, they were asked to indicate with which fingers they spontaneously type both the first
487 and the second letter of the respective dyad.

488 *Data analysis.* For each trial, a typing score was computed attributing 0 to trials in which
489 participants did not follow the expected criteria (i.e., did not type fluent dyads with two
490 different hands or did not type non-fluent dyads with the same hand) and 1 to trials in which
491 participants adopted the expected criteria (i.e., fluent dyads typed with two different hands

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3 492 and non-fluent dyads with the same hand). Then, binomial tests were applied over all trials to
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5 493 test the probability of the participants' typing scores being greater than chance level (0.50)
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7 494 and thus, indicating them to be more likely to use the expected criteria for typing fluent and
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9 495 non-fluent dyads.

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11 496 *Results.* The probability of success (typing score = 1) for fluent dyads typing scores was .74
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13 497 whilst probability of success for non-fluent dyad typing scores was .73. Both binomial tests
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15 498 revealed significant effects (fluent dyads: 284 out of 384 trials were typed with due different
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17 499 hands, $p < .0001$; non-fluent dyads: 280 out of 384 trials were typed with the same hand, $p <$
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19 500 $.0001$), indicating that participants, in both types of dyads, are more likely to adopt the
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21 501 expected typing behavior based on the classification of fluent and non-fluent dyads.
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6 503**Appendix B**7
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9 504 **Text of the typing task.**10
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For Review Only

507

Appendix C

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Table C1. Columns consisting of non-fluent (left column) and non (right column)

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dyads shown to the participants at the end of the procedure to check for their

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perceived difference. See

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https://osf.io/9j3d4/?view_only=0e8fd9f21cf445329e21af4bdf172e26 for the

512

participants' responses.

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RT	GK
FR	FK
FT	JE
GF	MC
NM	CY
UH	DM
HN	IV
YU	KR
RG	RI
RV	RK
VR	HD
TF	YC
UM	CN
HY	EJ

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YM	IR
JN	IG

For Review Only